should be evidently a part of a whole composition. We have already indicated the mode of finding the colour of combination. There are many other points to be considered, the most important of which affect the variations, which it may be necessary to make in the colour of combination, either by variation of hue, or by the introduction of melodising colours.* It should be recollected that a lively style of colouring should, in many cases, be preferred to a sombre; but that in rooms devoted to festivities, the decoration should not be so excessive as to nullify the dresses, and ornamental accessories of the occasion. Variety is, in fact, the foundation of pleasing arrangement of colour.

The subject of colour might be considered at much greater length. We have here endeavoured to set forth the previous considerations, which it is necessary to meet:—the mode of applying particular colours, in combination with each other, with their comparative powers and intensities, along with the propriety of materials, and their imitations, must be left for a future opportunity, or for the investigation, which we have endeavoured to direct.

E. H.

* On the subject of colour, as adapted to interior decoration, consult, Hay "On Harmonious Colouring, adapted to Interior Decoration," Field's "Chromatography," Field's "Chromatics," "Athenæum," Dec., 1843.

THE BURSTING OF A CAST-IRON TANK,

AT THE LIVERPOOL AND HARRINGTON WATER-WORKS.

Amongst the numerous and fatal accidents that are daily occurring to keep the public mind in a state of feverish excitement, that which took place at the Liverpool and Harrington Water-works, on the 25th of December last, is the most extraordinary in its character and consequences that has come under consideration for a great number of years. We allude to the sudden and unexpected rupture of a cast-iron tank or cistern, by which several houses were demolished, five human beings hurried into eternity, and eight others dangerously bruised and mutilated. This cistern was one of uncommonly large dimensions, said to be capable of containing 200,000 imperial gallons, or upwards of 32,000 cubic feet of water, a quantity which, when compared with the average supply of the principal London companies, is amply sufficient for the accommodation of more than 1,100 tenements, or about three times the number of houses in the Strand of London. This simple statement will serve to give the practical reader a more correct and comprehensive idea of the immense size of the vessel, than any thing that can be advanced in reference to its linear dimensions and cubical contents.

The tank was of an oblong or rectangular prismatic form, and according to the evidence of Mr. Howell, under whose superintendence it was constructed, its length was 71 feet, width $24\frac{1}{2}$ feet, and depth 20 feet; other dimensions have been given, but as the individual just mentioned made the drawings, and furnished the various details for the construction, we are justified in giving the preference to the data which he has supplied to us. A rectangular vessel for the retention of water under a high head of pressure, is the very worst form that could be chosen for the purpose; its adoption in any case is highly objectionable, and betokens great ignorance of the fundamental laws of fluid action; but in the present instance, where the failure has been attended with such disastrous results, it entails a fearful responsibility on the parties by whom the vessel was erected. There are, it is true, some extenuating points in the case, for it appears from the evidence of Mr. Thompson, the manager and chief clerk of the Liverpool and Harrington Water-works, that the foundation was prepared by the Harrington Company themselves, but under the constant superintendence and direction of Mr. Howell; this circumstance frees the other party from blame, in so far at least as form and position are concerned, but nothing can be admitted as a palliative for the want of strength in the materials, or an excuse for the imperfections of workmanship, the one or the other of which must have led to the catastrophe. There can be no doubt about the matter, for if the materials were of such a quality and strength as to sustain the estimated pressure with safety, then the natural inference is, that the workmanship was defective; and, on the other hand, if the workmanship was such as to answer all the purposes for which it was intended, then the obvious conclusion is, that the materials were either imperfect in structure, or deficient in the estimated strength. The probability, however, is that both were faulty, and that the effect of fluid pressure had not been properly considered, according to the established laws of hydrostatics.

Taking the dimensions as elicited from the evidence of Mr. Howell, and assuming them to be the correct internal measurements of the vessel, the rules of mensuration give—

$$71 \times 24\tfrac{1}{2} \times 20 = 34790 \text{ cubic feet for the contents of the tank;}$$

and this, when estimated in imperial gallons, becomes—

$$34790 \times 1728 \div 277{\cdot}274 = 216814 \text{ gallons.}$$

The estimated content of the vessel, from which the pressures appear to have been severally deduced, is 200,000 gallons; being in defect of the true contents by a quantity not less than 16814 gallons. But, according to the evidence, the rupture took place when the vessel was filled to the depth of only 17 feet, in which case the cubic content was only $29571\frac{1}{2}$ feet, or 184293 gallons; differing from the total contents by 32521 gallons; a very important difference, indeed, as regards the effect of the pressure induced by it on the upright sides of the containing vessel.

The following are the chief principles of fluid pressure which are more immediately involved in the inquiry; they are given here with the view of placing them directly under the eye of the reader, and saving the trouble of referring to books on hydrostatics, where they are severally demonstrated and treated in a more scientific manner:—

1. When a non-elastic fluid is at rest in a vessel whose base is horizontal, equal parts of the base are equally pressed by the fluid.

2. All the parts of a non-elastic fluid press equally at the same depth.

3. The pressure of a non-elastic fluid at any depth is directly proportional to that depth.

From these properties we infer, that the pressure of a non-elastic fluid on a horizontal plane, is equal to the weight of a column of the fluid, whose base is the area of the plane, and altitude equal to the depth of the plane below the upper surface of the fluid.

4. When a non-elastic and quiescent fluid is urged by its own weight, it presses equally in all directions, whether upwards, downwards, horizontally, or obliquely.

5. When a non-elastic fluid is at rest in an upright rectangular vessel, the whole weight of the fluid, or the pressure on the bottom, is to the pressure on the upright containing surface, as the area of the bottom is to half the area of the upright surface; or to the area of one side and one end of the vessel.

6. The pressure of a non-elastic fluid against any upright surface whatever, is equal to half the weight of a column of the fluid, whose base is the surface pressed, and altitude the same as the altitude of that surface; or it is equal to the weight of a column of the fluid, whose base is the surface pressed, and altitude equal to the depth of the centre of gravity of that surface, below the upper surface of the fluid.

7. The pressure of a non-elastic fluid on a surface any how placed in it, whether perpendicularly, horizontally, or obliquely, is equal to the weight of a column of the fluid, whose base is equal to the surface pressed, and altitude equal to the depth of the centre of gravity of that surface, below the upper surface of the fluid.

These are the several hydrostatic principles that come into operation in this and similar inquiries; they have long been familiarly known to mathematicians and philosophers, and are duly appreciated by practical men generally, for the great usefulness in the proper conduct and management of water; yet here is an instance in which these well-known and established laws, as well as the rules deduced from them, notwithstanding their simplicity and great practical utility, appear to have been altogether neglected, if we are allowed to judge from the failure of the vessel itself, and from the evidence of those individuals who were examined as to its cause. The following calculations will prove our position.

If the tank were full of water to the depth of 20 feet, the total pressure upon one of its upright sides would be equivalent to the weight of 14200 cubic feet of water; for by the rules of mensuration, we have

$$71 \times 20 = 1420 \text{ square feet of surface,}$$

and by the sixth hydrostatical principle, the pressure on that surface is

$$1420 \times 10 = 14200 \text{ cubic feet,}$$

or when expressed in pounds avoirdupois, it is

$$14200 \times 62\tfrac{1}{2} = 887500 \text{ lbs.}$$

This gives an average pressure of 625 lbs. upon a square foot of surface, or 4·34 lbs. to the square inch; but at the instant of fracture, according to the evidence, there was not more than an average pressure of $3\frac{1}{2}$ lbs. to the square inch, shewing a culpable deficiency in the strength of the vessel compared with what it ought to have been in the case of perfect safety. It is moreover stated, that at the instant of fracture, the vessel was only filled to the depth of 17 feet, and this is said to be equivalent to a weight of 750 tons: now, at the depth of 17 feet, the cubic contents, as we have already seen, is $29571\frac{1}{2}$ feet, for by the rules of mensuration, we have

$$71 \times 24\tfrac{1}{2} \times 17 = 29571{\cdot}5 \text{ cubic feet:}$$

and because a cubic foot is equivalent in weight to $62\frac{1}{2}$ lbs. it is

$$29571{\cdot}5 \times 62{\cdot}5 \div 2240 = 825 \text{ tons.}$$

Here, then, the difference between the estimated weight at the time of fracture, and the actual weight, according to the dimensions, is 825—750=75 tons in defect; now, to what cause can we attribute these glaring discrepancies, but to a total neglect of the rules of calculation; a neglect for which practical men in general are highly to be censured, but more especially when the calculations are of such a simple nature as to come within the reach of all. If we calculate the mean pressure at the depth of 17 feet, we shall find it to be 3·69, or 3·7 lbs., a result which agrees more nearly with the evidence than any other statement that has yet been examined. The whole weight of the water in the tank when full, would be 970·7 tons, and this is equivalent to the pressure on the bottom of the vessel; as appears from the first of the preceding hydrostatic principles.

It has been shewn above, that the pressure on one side of the vessel when full, is 887500 lbs., or 396·2 tons; but since water presses equally in all directions, by the fourth hydrostatic principle, the same amount of pressure is transmitted to the opposite side, so that the whole amount of force tending to burst the vessel transversely, is $396{\cdot}2 \times 2 = 792{\cdot}4$ tons; and this is the force which has to be provided against in estimating the strength of the materials.

Again, by the rules of mensuration, the area of one of the upright ends of the vessel is $24{\cdot}5 \times 20 = 490$ square feet, and according to the sixth hydrostatic principle, the pressure on that area is equivalent to the weight of 4900 cubic feet of water, or 306250 lbs.; consequently, the pressure on both ends is $306250 \times 2 = 612500$ lbs., or 273·43 tons; and this is the force which tends to burst the vessel longitudinally, one-half of it acting in each direction. The whole pressure on the upright surface of the vessel is, therefore, $792{\cdot}4 + 273{\cdot}43 = 1065{\cdot}83$ tons; the total pressure on the upright surface and base together, being $1065{\cdot}83 + 970{\cdot}7 = 2036{\cdot}53$ tons. The total pressure on the upright surface, however, may be obtained more readily as follows:—

$$\overline{71 + 24{\cdot}5} \times 20^2 \times 62{\cdot}5 \div 2240 = 1065{\cdot}83 \text{ tons, as before.}$$

But the amount of pressure on the same upright surface may also be determined in a manner somewhat different, by the application of the fifth hydrostatic principle, for the whole area of the upright surface, is

$$\overline{71 + 24{\cdot}5} \times 40 = 3820 \text{ square feet, and the half of this is } 3820 \div 2 = 1910 \text{ square feet;}$$

but the area of the bottom is $71 \times 24{\cdot}5 = 1739{\cdot}5$ square feet, and we have already seen that the pressure on it, or the whole weight of water in the tank when full, is 970·7 tons; hence it is $1739{\cdot}5 : 970{\cdot}7 :: 1910 : 1065{\cdot}83$ tons, the same as before.